Universal Serial Bus (USB)
Expanding the Port Count & Bandwidth for Desktop Motherboards into 2003

R1.0
11/12/01

*This paper is an update to Alex Warshofsky's 1999 paper "Universal Serial Bus (USB) How Many Ports and How To Get There?"

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References:
http://www.usb.org/
http://developer.intel.com/technology/usb
http://developer.intel.com/technology/easeofuse/USBwhite3.PDF
http://www.microsoft.com/hwdev/NewPC/default.htm
PC Data

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I. Introduction

Universal Serial Bus is a standardized peripheral connection developed by Intel and other industry leaders that supports multiple device connectivity, improves the performance of the PC peripheral connection, greatly simplifies the user installation experience, and allows for digital multimedia integration. By virtually eliminating the hassle of opening the computer case to install cards that are necessary for certain devices, and by supporting hot plug capabilities, USB eliminates most of the guesswork involved in peripheral installation.

Update

It is important to note that this white paper is an update to one written by Alex Warshofsky in 1999, entitled "Universal Serial Bus (USB) How Many Ports and How To Get There?" Alex's white paper gives a general introduction to Universal Serial Bus (USB), as well as outlining the transition from parallel and serial ports to USB technology.
His paper can be found at the URL below:

http://developer.intel.com/technology/easeofuse/USBwhite3.PDF

USB 1.1

Many industry leaders developed the Universal Serial Bus in 1995, including Intel. The major objective of USB was to create an external expansion bus that made peripheral connectivity to the PC easy.
Today, USB enjoys tremendous success in the marketplace, with most PC peripherals using it.

Bandwidth — USB1.1 has a maximum throughput of 12 Mbps, a significant improvement over both serial (110Kbps) and parallel ports (2Mbps).

USB 1.1 is sufficient for many PC peripherals such as keyboards, mice, digital joysticks, floppy drives, digital speakers, and low-end printers. Existing USB1.1 based peripherals will also operate with no change required in USB2.0 systems.

Expandable — Between 1996 and 2001, there were usually between two and four USB1.1 ports integrated into Intel® chipsets. If one wanted to add more ports, there are two ways: hubs and a discrete host controller (HC) on a motherboard. More ports are being added on Intel chipsets today, as indicated below.

Implementations — Intel has released many platforms that take advantage of USB1.1 technology. The most recent additions to the Intel family are Intel® Desktop Board D845HV and D845WN, each with up to 7 USB1.1 ports. The table given below lists just some of Intel desktop boards that take advantage of USB1.1 technology.

Intel® Desktop Board	Processor	USB ports	Config.
D845WN	Pentium® 4 processor	7	4 Back Panel 2 Front Panel 1 to CNR
D845HV	Pentium® 4 processor	7	4 Back Panel 2 Front Panel 1 to CNR
D815EEA	Pentium® III processor or Celeron® processor	4	2 Back Panel 2 Front Panel
D815EPEA	Pentium® III processor or Celeron® processor	4	2 Back Panel 2 Front Panel
D850MD	Pentium® 4 processor	7	4 Back Panel 2 Front Panel 1 to CNR
D850MV	Pentium® 4 processor	7	4 Back Panel 2 Front Panel 1 to CNR
D850GB	Pentium® 4 processor	4	2 Back Panel 2 Front Panel

Table1: Intel Platforms integrated with USB1.1 technology

Ease of Use Through USB

Legacy dependent I/O connectivity is decreasing significantly with the increased availability of USB in PC's along with USB enabled peripherals in the market today.

USB eliminates the need for users to open the system case by expanding the PC's capabilities via an external port. Also, USB allows users to run multiple devices simultaneously from a PC without complex software installation or add in cards. Another great feature of USB is the plug and play experience it provides by automatic detection and installation of these devices. This creates a simpler way of connecting external devices for the end user.

Microsoft* Windows XP* operating system also provides significant improvements to the user's USB peripheral installation experience. Previously when installing a USB device, a successful installation was highly dependent on whether the user inserted the device installation CD first, or whether they plugged the device to the PC first. Failure and customer support calls often resulted from choosing the latter path. Now with new drivers available as well as improved software user interfaces in XP, USB installation will usually succeed regardless of the installation task path chosen by the user. In fact,

with Windows XP and USB technology, most applications have drivers native to the operating system and will be able to plug in and work without installing extra drivers.

Hi-Speed USB2.0

A core team led by Intel developed the specifications for Hi-Speed USB, also known as USB2.0, in April 2000. The goal of USB2.0 is to enhance the performance of the already ubiquitous USB solution by 40x, while not having to change connectors or cables. In early 2001, vendors began shipping USB2.0 add-in cards and notebook PC cards. By summer of 2001, PC peripheral vendors started shipping products, mostly in the storage area (hard disk drive, CD-RW, DVD).

Hi-Speed USB will allow PC peripherals to perform at higher levels and with more functionality, including higher resolution uncompressed data cameras, next generation scanners and printers, fast storage units, and faster broadband Internet connections.

Hi-Speed USB has the Enhanced Controller Interface (EHCI) and it defines the architecture for a USB2.0 capable host controller and defines register (hardware/software) interface for a Hi-Speed capable host controller.

Bandwidth — Hi-Speed USB has a maximum throughput of 480 Mbps. In comparison, USB 1.1 has a maximum throughput of 12 Mbps. This increases the data throughput providing a data rate of *40 times faster* than USB 1.1. Additionally, the greater bandwidth increases the number of devices that can use USB2.0 at the same time.

Expandable — Starting in 2002, PCs will be shipping with a minimum of 6 USB2.0 ports integrated into the chipset. However, one can increase ports by simply adding a hub. Additionally, PC OEMs will have the opportunity to add even more ports with a USB2.0 or USB1.1 controller on the motherboard.

Due to the increase in overall bandwidth, one can now simultaneously run more devices over that of USB1.1. Suppose an end-user with USB1.1 technology has a mouse, keyboard, high-speed printer, and camera hooked up to his/her system. When the end-user wants to add additional peripherals, such as an mp3 player or external hard drive, there may not be enough bandwidth available. Remember that all the peripherals are sharing 12Mbps of available bandwidth, and the end-user could very easily exceed this and get an error message from the system instructing the user to unplug a peripheral. USB2.0 will increase the throughput of these applications, as well as allow the end-user to add many more peripherals and not exceed the available bandwidth.

Compatibility — USB2.0 is fully forward and backward compatible. So all USB1.1 peripherals will work in the Hi-Speed USB2.0 ports. These peripherals will still only run at the 12Mbps and not 480Mbps.

Implementations — Intel has begun releasing platforms that take advantage of Hi-Speed USB technology. Intel Desktop Boards D850MV, D850GB, D845BG all have

optional discrete Hi-Speed USB technology. The table below contains Intel product families that use Hi-Speed USB technology.

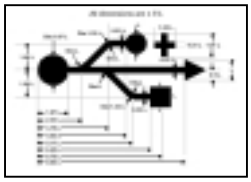
Intel® Desktop Boards	Processor	USB ports	Configuration
D850GB	Pentium® 4 processor	5	2 Back Panel, 2 Front Panel, 1 to CNR
D850MV	Pentium® 4 processor	5	2 Back Panel, 2 Front Panel, 1 to CNR
D850MV	Pentium® 4 processor	7	USB2.0: 2 Back Panel, 2 Front Panel, 1 to CNR USB1.1: 2 Back Panel (from chipset)
D845BG	Pentium® 4 processor	5	2 Back Panel, 2 Front Panel, 1 to CNR

Table 2: Intel Platforms with Hi-Speed USB

Improvements from USB1.1 to 2.0

USB 2.0 is an evolution of USB 1.1 specification, which provides much higher performance interface. An important aspect of the 2.0 specifications is that all of the USB1.1 peripherals already existing will work in an USB2.0-capable PC. In other words, USB2.0 is fully forward and backward compatible.

Impact to User — From the user's perspective, a Hi-Speed USB system will look very similar to a system using USB1.1, but it will have a higher bandwidth. In cases where a system has both USB2.0 and USB1.1 ports, a Hi-Speed port will be clearly defined by the following icon (shown below).



The icon shown here may be used to label any PC, host or hub USB port that supports USB 2.0 performance in platforms that have both USB1.1 and USB2.0 ports (mixed ports).

There will be an inevitable period of time in the industry when systems transition from USB1.1 to USB2.0. In this timeframe, some PCs will have mixed ports. Note that the figure above has an additional plus sign, which differentiates 2.0 ports from 1.1 ports. It is worth mentioning again, that *this plus will only appear in systems with mixed ports to clarify which port is the Hi-Speed USB2.0.*

Successfully managing the USB1.1 to 2.0 transition — A design guideline found at the following URL, http://www.usb.org/developers/data/icon_design.pdf, provides recommendations on this transition period in the industry. When mixed ports might be visible to the end-user, Intel recommends labeling as described below:

1.) Add-in cards sold as an upgrade option: the USB icon with a "plus" sign should designate USB2.0 ports on the add-in card.

2.) Platforms with a CNR card that have USB ports visible to the user should match the general-purpose ports on the PC chassis, and be labeled in the same way.

3.) Platforms with a USB1.1 chipset and a discrete USB2.0 host controller on the motherboard

   a. If the discrete USB2.0 host controller supports all the necessary USB ports on the chassis, then all are USB2.0 ports, the ports are labeled with the "plus" icon and the chipset ports should be disabled.

   b. If the discrete host controller does NOT support the desired number of USB ports, then up to two USB1.1 ports from the chipset should be placed on the far left near the PS/2 ports. These ports should be marked with the standard USB icon. The rest of the USB2.0 ports should be designated with the USB icon with the "plus" sign.

4.) Platforms with USB2.0 host controller integrated into the chipset

   a. If the chipset supports desired number of USB ports, then all ports should be USB2.0 and designated with the "plus" sign.

   b. If the chipset does not support the desired number of USB ports, then either

      i. USB2.0 hub can be used or

      ii. USB1.1 hub can be used. In this case, the two USB1.1 ports should have the standard USB icon and the USB2.0 ports should be marked with the "plus" sign.

Impact to PC Manufacturer — Hi-Speed USB2.0 will provide system manufacturers the ability to connect to high performance peripherals at a cheaper price. The addition of these capabilities will be added with little impact to overall system cost. In fact, with the elimination of SCSI adapters some systems cost could decrease. This also allows the PC manufacturers to simplify construction because only USB connectors will be needed for peripheral expansion.

Impact to Peripheral Manufacturer — As already mentioned, today's USB devices will be fully compatible with a USB 2.0 system. The added bandwidth and capabilities of USB 2.0 should actually increase the market segment, the amount of applications, and performance attributes for USB peripherals. Designing a Hi-Speed peripheral will be a similar engineering effort to that of designing a USB 1.1 peripheral. Because low-speed peripherals such as keyboard and mouse do not require the higher bandwidth, they will

not need to be redesigned to support version 2.0 in order to retain the absolute lowest manufacturing cost.

Brief Port Count History

- Initially when USB1.1 was introduced, most systems came standard with two ports. These ports were used as a transition to be used for a printer and one new device.
- Later systems added two more USB1.1 ports for a total of four. Two ports were added to the front panel for end-user ease of use.
- Finally, by 2002 systems will be shipped with 6 Hi-Speed USB ports. These six ports allow the end-user the ability to plug-in a keyboard and mouse.
- In the future, eight Hi-Speed USB2.0 ports are expected to be available in systems. These will allow for increased connectivity for additional devices, such as speakers and MP3 players.

II. Marketing Trends

USB connectivity is a ubiquitous PC peripheral standard. Not only are keyboards, mice, printers, scanners, cameras, microphones, and speakers still using USB, but now devices such as PDA's, video conferencing cameras, wireless Network Interface Cards (NIC), and MP3 players all hook up to a USB port. As the market segment continues to expand with these peripherals, the number of USB ports on your PC becomes increasingly more important.

Fixed vs. Attached Peripherals

When connecting peripherals to USB ports, the end-user has the option of connecting to *front panel or back panel ports*. The front panel ports are generally for peripherals that do not stay connected all the time. Examples of these are mp3 players or digital cameras. Front panel ports are slightly more expensive than back panel ports because of the extra internal cable required for connecting to the motherboard.

On the other hand, the end-user has many peripherals that stay attached to the system most of the time. Examples of these fixed peripherals are printers, scanners, or web cameras. The typical end-user will not be constantly detaching a printer. We need both fixed (back panel) and attachable (front panel) ports because of the wide-variety of peripherals that are currently in the market and that will be available in the future.

Future USB Trends

In looking at marketing trends, it is important to look out into the future of USB technology. Below are tables that show how many USB ports computers will have based upon which marketing segment and type of processor. The tables below define three

marketing segments of PCs: performance, mainstream, and value. Systems considered to be performance PCs are generally those with processors that have the fastest clock rates, such as the Pentium® 4 processor. Mainstream PCs are those with average clock rates, and systems considered in the value segment generally have processors with slower clock rates.
The corporate market consists of businesses buying Intel® processors while the consumer market consists of households.
Tables 3 and 4 below are broken into time frames, beginning with late 2001 and continuing until 2003 with projected port counts for the three marketing segments.

	Consumer	**Corporate**
Performance	5 USB2.0	5 USB2.0 **or** 4 USB1.1
Mainstream	7 USB1.1 **or** 5 USB2.0	5 USB2.0 **or** 4 USB1.1
Value	4 USB1.1	4 USB1.1

Table 3: Late 2001, Early 2002 Port Count

	Consumer	**Corporate**
Performance	6 USB2.0	6 USB2.0
Mainstream	6 USB2.0	6 USB2.0
Value	6 USB2.0 **or** 4 USB1.1	6 USB2.0 **or** 4 USB1.1

Table 4: Late 2002, Early 2003 Port Count

Elimination of Legacy Ports

For the computer industry to continue the momentum gained in the late twentieth century, improved technologies that offer better performance at lower costs are essential. However, without consumer awareness, the potential of many of these technologies will never be fulfilled. One way to gain this momentum is to eliminate legacy technologies that slow the progress made with newer technologies.

According to Intel, a legacy feature is one in which there exists a faster, superior, easier, or less expensive alternative. For the longest time, the ISA bus was a legacy feature that remained a component of PC platforms even though superior connectivity solutions existed, such as PCI. However, it is important to note that PCI is not a plug & play experience for the end-user. In order to install a component to PCI, the user has to open up the box, re-boot, and deal with complex installation processes. This is not the case with USB technology. USB does allow for true *plug & play* experience as well as *hot plugging*.

Removing such legacy features can advance the industry by making the PC easier to use, simplifying design of the PC, and increasing flexibility in form factors and PC platforms. However, as the industry eliminates legacy ports, we increase the number of USB ports necessary. For example, in the future, we fully expect that mice and keyboards will no longer have PS/2 to plug into and will rely upon USB technology.

Microsoft Corporation considers a legacy feature to be one in the system based on older technology for which compatibility continues to be maintained in other system components, even though equivalent or better functionality is provided using newer, more flexible technologies. Colloquially, a legacy-free system is a design that reports itself to the operating system as having no ISA, serial, parallel, PS/2, and FDC components, and that is designed to enable deterministic operating system control of all components. Legacy-free system support can be found from Microsoft at the following website:

http://www.microsoft.com/hwdev/NewPC/default.htm

In fact, the PC industry has begun to reach a "critical mass" on the variety of ports for peripherals to plug into. The industry continues to pump in these new technologies, but it fails to remove older technologies, such as parallel, serial, and PS/2 ports. However, by 2003 the PC industry should be completely free of PS/2 and serial ports because the price premium for USB has dropped. Parallel ports may be around a little longer only because of all the printers that still exist with parallel connections. The graph below shows the percentages of USB for each peripheral in the retail market as of June 2001.

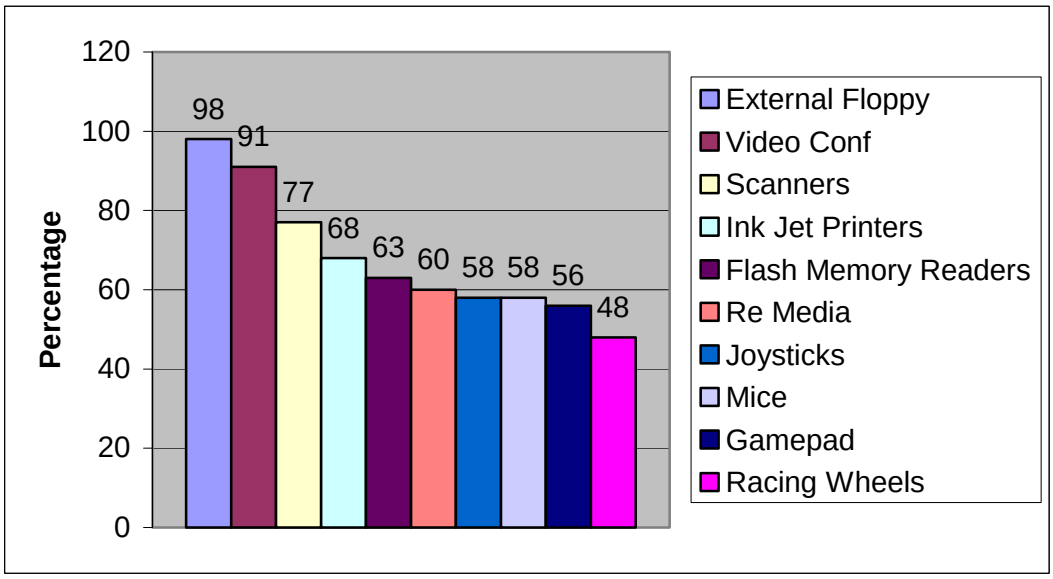


Figure 2: Percentage of USB peripherals in the retail market (as of June, 2001)

The move to a legacy-free PC architecture provides benefits for both the end-user and the PC industry:

- End-users benefit because legacy-free systems can boot and resume faster, are significantly more reliable, and eliminate many causes for incorrect configuration
- The PC industry benefits by reducing system costs and support costs

Short-term goals for legacy removal for the industry are to:

- Demonstrate end-user benefits by focusing device expandability on Plug and Play buses. This also reduces some component costs and support exposure for OEMs.
- Drive market acceptance of legacy-free systems to support the long-term goals.

Long-term goals for legacy removal for the industry are to:

- Create a PC architecture that allows designers to make architectural changes with zero impact on the end-user from a compatibility or usage perspective.
- Continue to improve ease of use for end-users

III. Implementation Options

Today, the average PC comes with at least 4 USB ports integrated into the chipset. However, a design methodology known as 'Flexible USB' allows for additional USB ports to support these evolving marketing conditions. These conditions include legacy reduction, USB to CNR, and auxiliary internal USB ports for future peripheral migration.

‘Flexible USB’ supports USB1.1 ports only, USB2.0 ports only, or a combination of both.

Roles of the USB2.0 Hub

Adding a hub to PC architecture will increase the number of USB ports. It is important to realize that the hub will share bandwidth with the host controller. In other words, a Hi-Speed USB2.0 hub will share the 480Mbps of the Intel chipset integrated with Hi-Speed USB. In comparison, a discrete controller would provide its own bandwidth.

A USB2.0 hub will accept the higher-speed transactions at the faster time rate of 480Mbps and will deliver them to the higher-speed peripherals, as well as USB1.1 peripherals. In the case where the hub communicates with an attached USB2.0 peripheral (high-speed peripheral), the hub repeats this peripheral’s signals on appropriate USB2.0 upstream and downstream cables just as a USB1.1 hub would repeat full and low-speed signals to USB1.1 peripherals. This allows the higher speed peripherals to utilize a greater majority of the bandwidth.

For a USB2.0 hub to communicate with a USB1.1 peripheral, the hub contains a mechanism that supports the concept of matching the lower-speed data rate. In other words, the hub manages the transition of the data rate from the high speed of the host controller to the lower speed of the USB1.1 device. This feature allows USB1.1 devices to work along with USB2.0 devices and not consume disproportionate amounts of USB2.0 bandwidth. The USB2.0 hub is designed to be as simple and cost effective as possible, as well as deliver the full capabilities of the lower-speed peripherals.

Roles of the Controller

A controller is a device that controls the data flow from your PC to your peripherals. Adding a USB controller will increase the number of ports to the existing architecture, usually by four. The advantage of a controller to add USB ports is that they do *not* share bandwidth but instead have their own. Therefore, those ports are not sharing the 480Mbps of the integrated ports; this will allow for more peripherals connecting at the same time and working even faster.

It is also important to note that one can add a controller “up” or “down” on the platform. Adding a controller “up” means inserting the controller into a PCI slot. This is usually done through a PCI add-in card. This is more expensive and not as user friendly as having one down on the motherboard. On the other hand, adding a controller “down” on the board means the silicon is soldered onto the motherboard. Many times when silicon is added “up” or “down” on a motherboard, it is referred to as a *discrete solution*.

Internal

Just about every motherboard produced has USB ports built into them. This is done using the host controller that is built into the Intel chipset. However, ports can be added internally by adding a hub or controller to the motherboard. As mentioned in the 'Controller' section, this can be done by adding a discrete solution "down" or "up" on the motherboard. This option is less costly than the end-user buying the external hub separately.

External

The hub and controllers can also be added external to the motherboard. However, this is the most expensive way to add USB ports because they are added to the system after production. Much of the expense of the external device is in the case and power supply. In some cases, a peripheral might have a hub already built into them.

Yesterday

Between 1995 and 2000 there were fewer combinations of the possible number of USB1.1 ports. PC architecture could use the USB1.1 ports integrated into the chipset, a USB1.1 hub, and even an additional 1.1 controller. This table assumes that there are four USB1.1 ports integrated into the chipset, 5 ports in a USB1.1 controller, and 4 ports in a USB1.1 hub. Table 6 displays the number of combinations with only USB1.1.

Chipset	Discrete Controller	Hub	Port Count	Comments
USB1.1	None	None	4	4 USB1.1 ports integrated into the chipset
USB1.1	None	USB1.1	7	4 ports in chipset w/ 1 routed to the Hub. Hub extends port count but shares the bandwidth (BW); less expensive than controller
USB1.1	USB1.1	None	9	4 ports in chipset and 5 ports in Controller. Controller adds 5 extra ports and bandwidth; more expensive than hub

Table 5: Port combinations with USB1.1 Integrated

Today & Into the Future

By 2003 all Intel chipsets should be integrated with Hi-Speed USB2.0. In late 2001 and early 2002, one can still have Hi-Speed USB by adding a discrete host controller. The table below assumes the following: Intel chipsets are integrated with 6 Hi-Speed USB ports, a Hi-Speed USB controller contains 5 ports, and a Hi-Speed USB hub contains 4 ports.

Chipset	Discrete Controller	Hub	Port Count	Comments
USB2.0	None	None	6	Six USB2.0 ports integrated into the chipset

USB2.0	**None**	**USB2.0**	**9**	**With 6 ports Integrated, one is routed to the hub. Hub extends port count but shares bandwidth; less expensive than controller**
USB2.0	**USB2.0**	**None**	**11**	**With 6 port Integrated and the Controller with 5 ports. Controller extends port count & has its own bandwidth; more expensive than hub**

Table 6: Port Combinations with USB2.0 Integrated

However, things become more complex when we realize the possible combinations of USB1.1 ports with USB2.0 ports. Table 8 demonstrates many of the possible combinations when combining USB1.1 ports with USB2.0 ports.

Chipset	Discrete Controller	Hub	Port Count	Comments
USB1.1	**None**	**4 x USB2.0**	**7 total 7 x USB1.1 0 x USB2.0**	**Note this solution is *not* practical. The hub shares bandwidth w/ the chipset and would only run at 12Mbps.**
USB2.0	**None**	**4 x USB2.0**	**9 total 0 x USB1.1 9 x USB2.0**	**6 ports integrated into the chipset, w/ one routed to the Hub; hub shares BW but is less expensive than controller**
USB1.1	**5 x USB1.1**	**None**	**9 total 9 x USB1.1 0 x USB2.0**	**4 ports integrated into the chipset, 5 in controller; controller has its own BW but is more expensive than a hub**
USB2.0	**5 x USB 1.1**	**None**	**11 total 5 x USB1.1 6 x USB2.0**	**6 ports integrated into the chipset, 5 in controller; controller has its own BW but is more expensive than a hub**
USB1.1	**None**	**4 x USB1.1**	**7 total 7 x USB1.1 0 x USB2.0**	**4 ports integrated into the chipset, w/ one routed to the hub; hub shares BW but is less expensive than controller**
USB2.0	**None**	**4 x USB1.1**	**9 total 4 x USB1.1 5 x USB2.0**	**6 ports integrated into the chipset, w/ one routed to the hub; hub shares BW but is less expensive than controller**
USB1.1	**5 x USB2.0**	**None**	**9 total 4 x USB1.1 5 x USB2.0**	**4 ports integrated into the chipset, 5 in controller; controller has its own BW but is more expensive than a hub**
USB2.0	**5 x USB2.0**	**None**	**11 total 0 x USB1.1 11 x USB2.0**	**6 ports integrated into the chipset, 5 in controller; controller has its own BW but is more expensive than a hub**

Table 7: Total Combinations w/ USB1.1 & USB2.0

It is important to realize that hubs share the bandwidth with the controller they are plugged into. A Hi-Speed hub will only have high-speed bandwidth (480Mbps) if it is attached to an Intel chipset that has Hi-Speed USB integrated. If a Hi-Speed hub is connected to an Intel chipset with USB1.1 integrated, all of the ports from the hub will be *sharing* the 12 Mbps!

On the other hand, the topology shown below demonstrates some of these combinations with Hi-Speed USB integrated into the chipset. One example shown below is of a low-speed hub (USB1.1 hub) routed into the chipset. The low-speed devices connected only

use full/low-speed, or 12Mbps. This means that a 6Mbps camera would use less than 2% of the USB2.0 bandwidth (6Mbps/480Mbps).

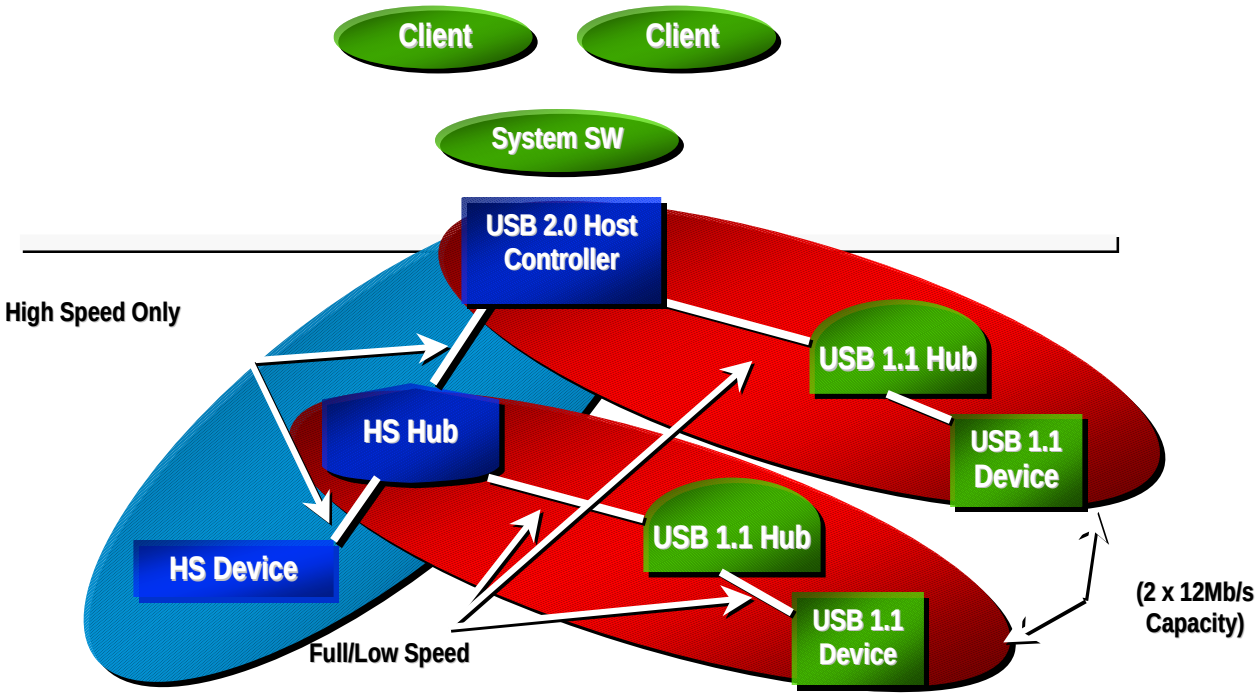


Figure 3: Topology of Hi-Speed USB and possible connecting options

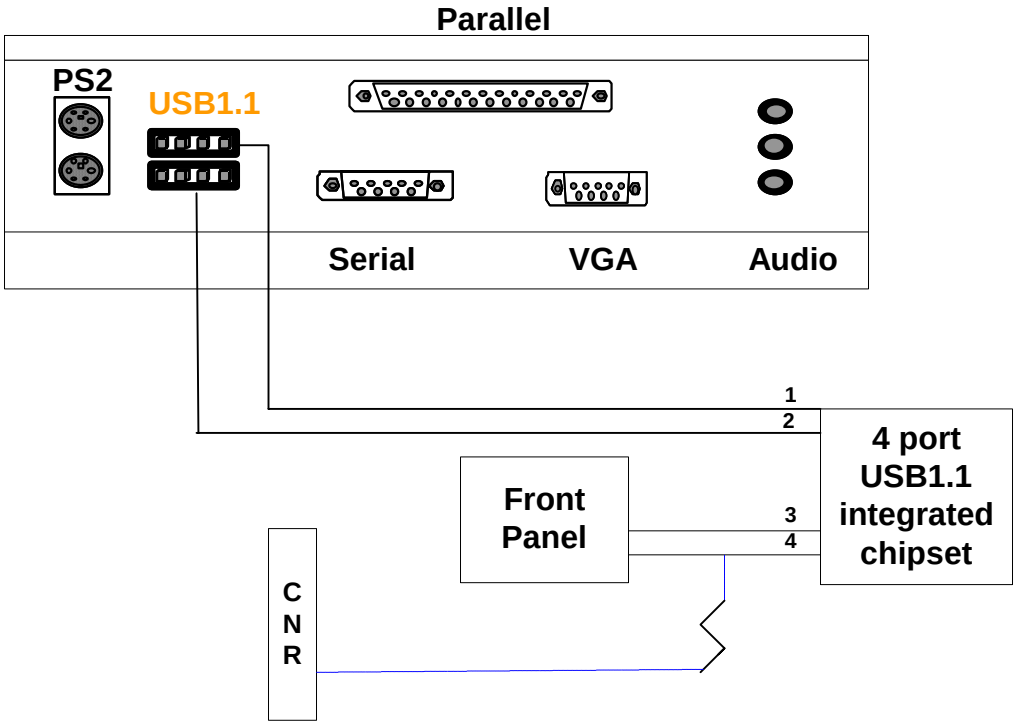
This topology also shows that when a Hi-Speed (HS) hub is plugged into a chipset integrated with HS, the devices will be able to share the 480Mbps, or the Hi-Speed bus.

IV. Solutions

Trying to determine the type and number of USB ports in a PC can be complicated. This section provides the recommendations on how to plan, configure, and route between four and eight USB ports from 2001 into 2003.

Option #1a

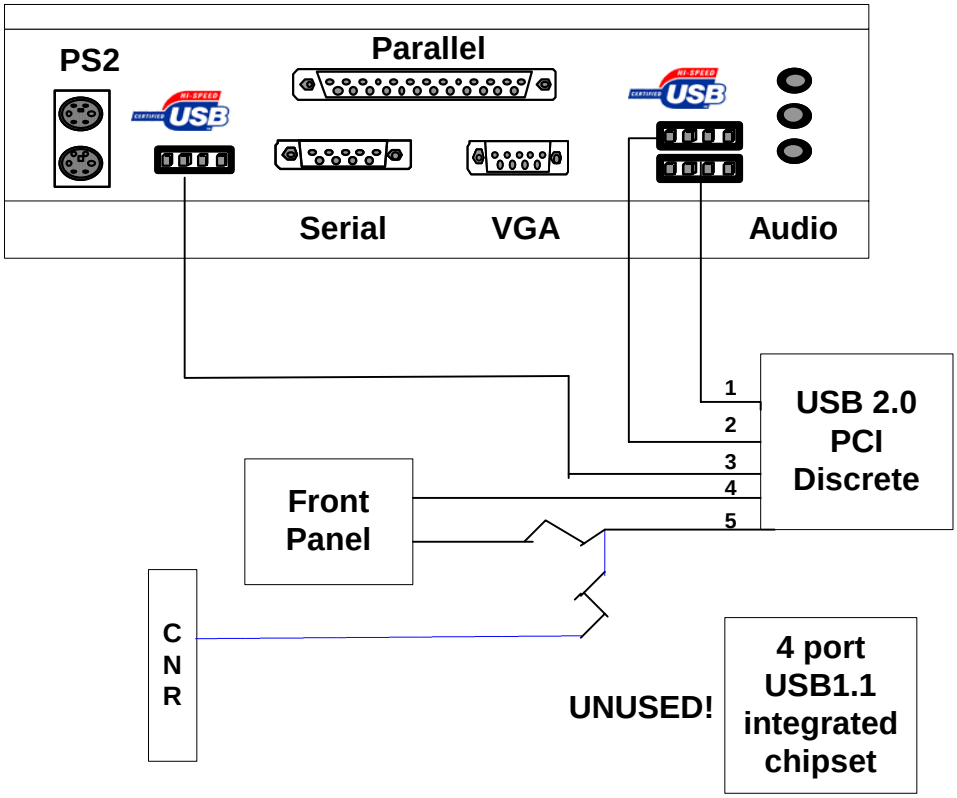
This combination has USB1.1 integrated into the Intel chipset and is reasonable for late 2001, early 2002 timeframe. This solution has two ports on the back panel, both USB1.1. It also contains two ports on the front panel, also USB1.1.
This option shows another configuration (shown below with a switch) would allow for two USB1.1 ports in the back panel, one front panel USB1.1, and one port to the Communications Network Riser (CNR). Notice that in the 2001 and 2002 timeframe serial and PS/2 ports still exist in the back-panel. This particular solution is an option on Intel Desktop Boards D850GB and D815EEA platforms.



Option #1b

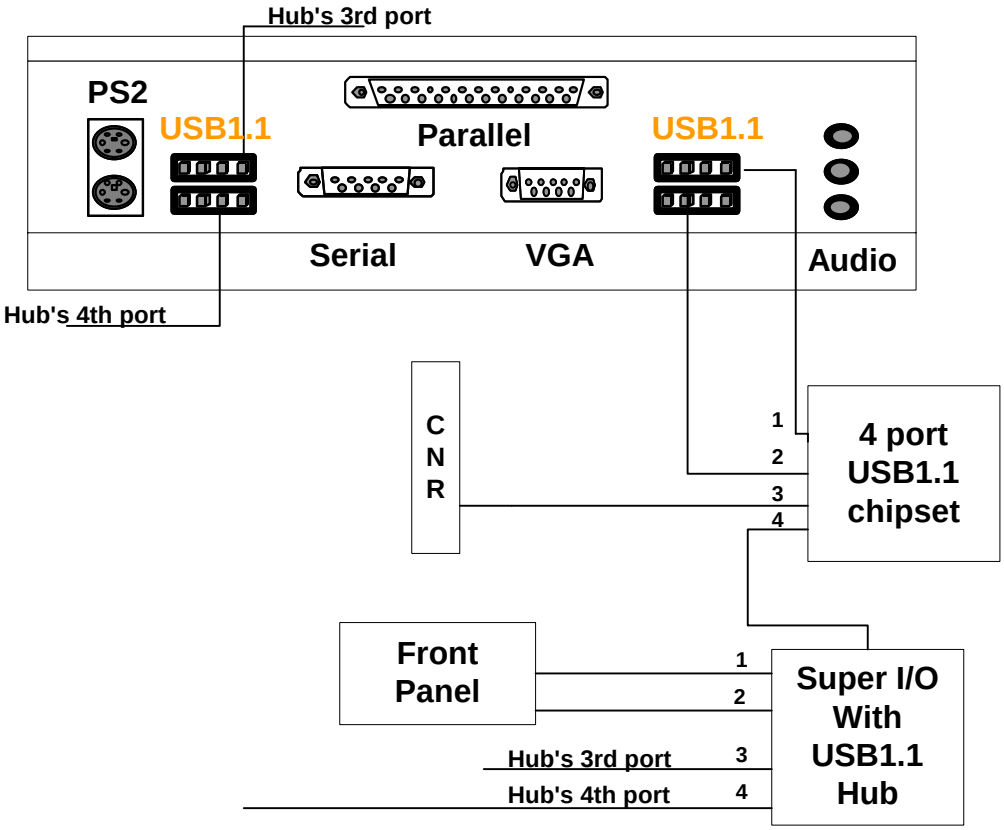
This is another option with USB1.1 integrated into the chipset. Therefore, in order to have Hi-Speed USB, we must add a discrete PCI device. The PCI device has five Hi-Speed ports, where two go to the front panel and three to the back panel. This option allows for another configuration with three to the back panel, one to the front panel, and one to CNR. Note that one downfall of this solution is that we have four unused USB1.1 ports from the chipset.

This option has been implemented with Intel D845BG platform.



Option #2

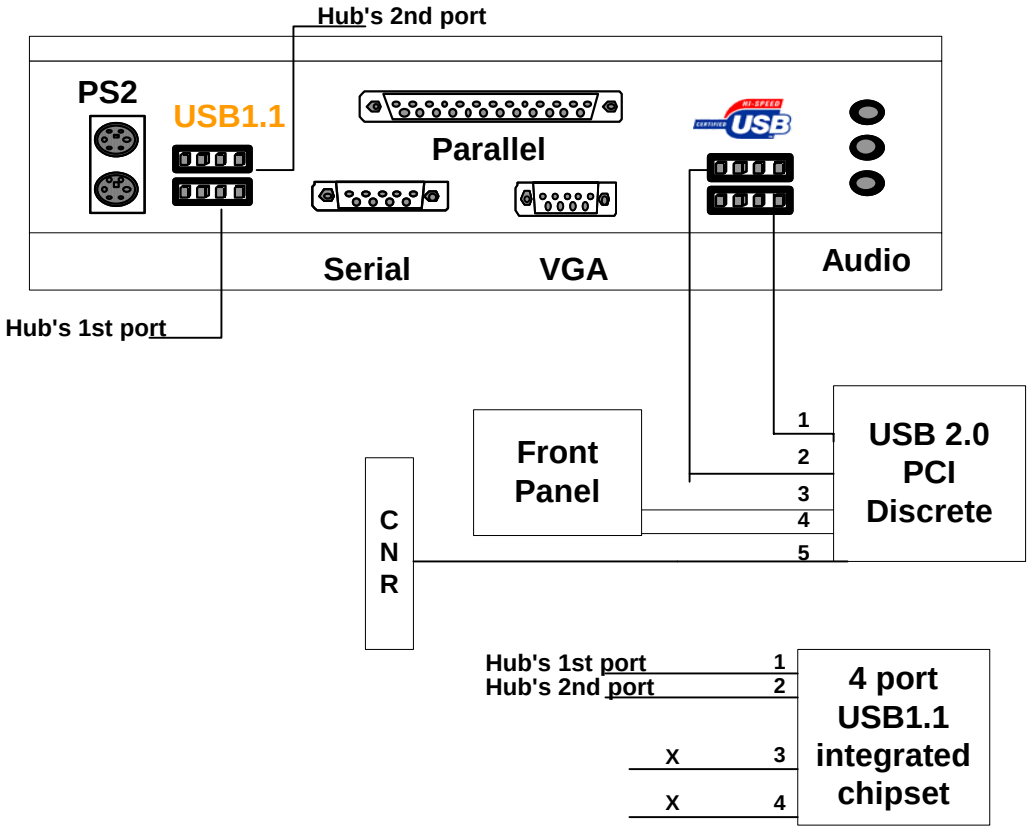
With 4 USB1.1 ports still integrated into the chipset, we can route to more peripherals by adding a USB1.1 hub. There are four USB1.1 back panel ports, two front panel ports, and a USB to CNR connection. This option is low cost and simple, however all these peripherals will be sharing 12Mbps bandwidth, given USB1.1.
(Note: Some Intel chipsets support two host controllers, therefore the bandwidth would actually be 24Mbps).



Option #3

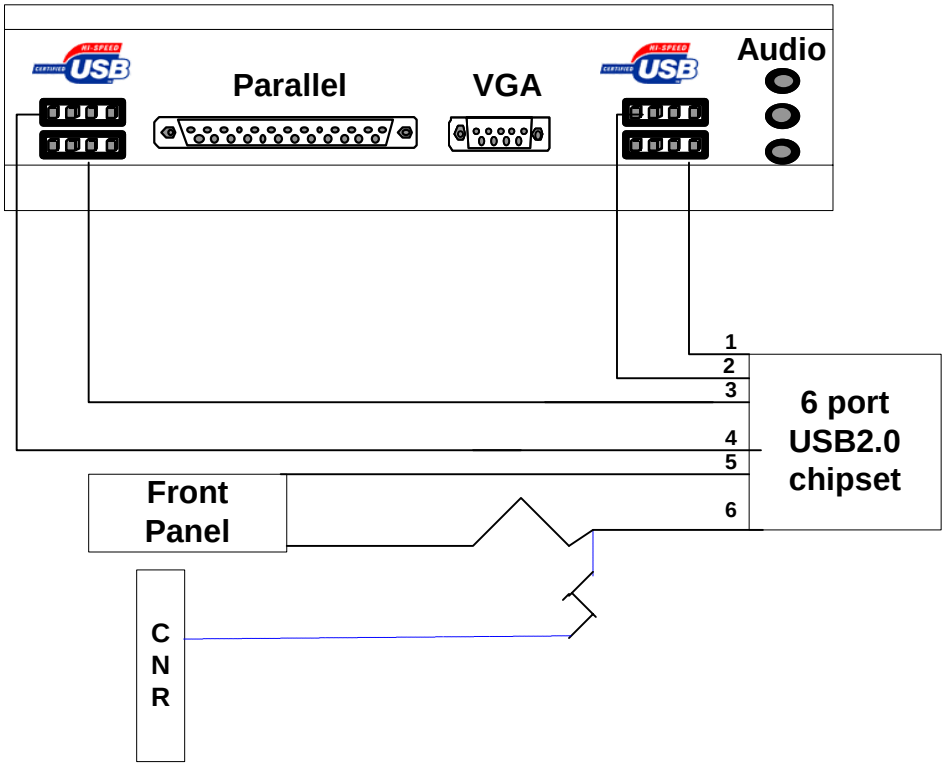
Option #3 has a chipset integrated with USB1.1, but allows for Hi-Speed USB by adding a discrete PCI device. This discrete controller has 5 USB2.0 ports, with two going to the back panel, two to the front panel, and one to CNR. Then, the last two back panel ports are USB1.1 and come from the actual chipset. This particular solution is seen in Intel Desktop Board D850MV.

This solution is advantageous in that it uses two of the ports from the chipset; however, there are still two unused USB1.1 ports.



Option #4

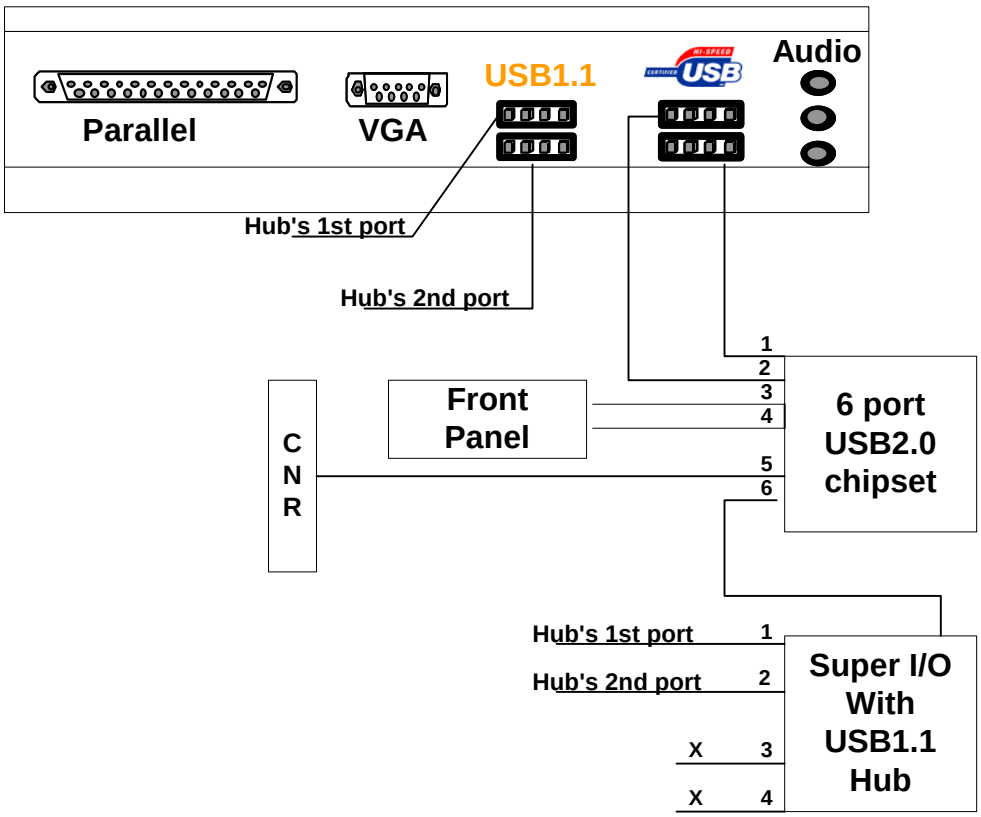
This option contains six Hi-Speed USB ports integrated into the chipset. Intel plans to release platforms with integrated USB2.0 technology in 2002. Two ports will be routed to the front panel and four to the back panel, with an option for one of the front panel ports to be routed to CNR. Each of these ports is Hi-Speed USB. Also, notice by 2002 the removal of legacy features, such as PS/2 and serial ports.



Option #5

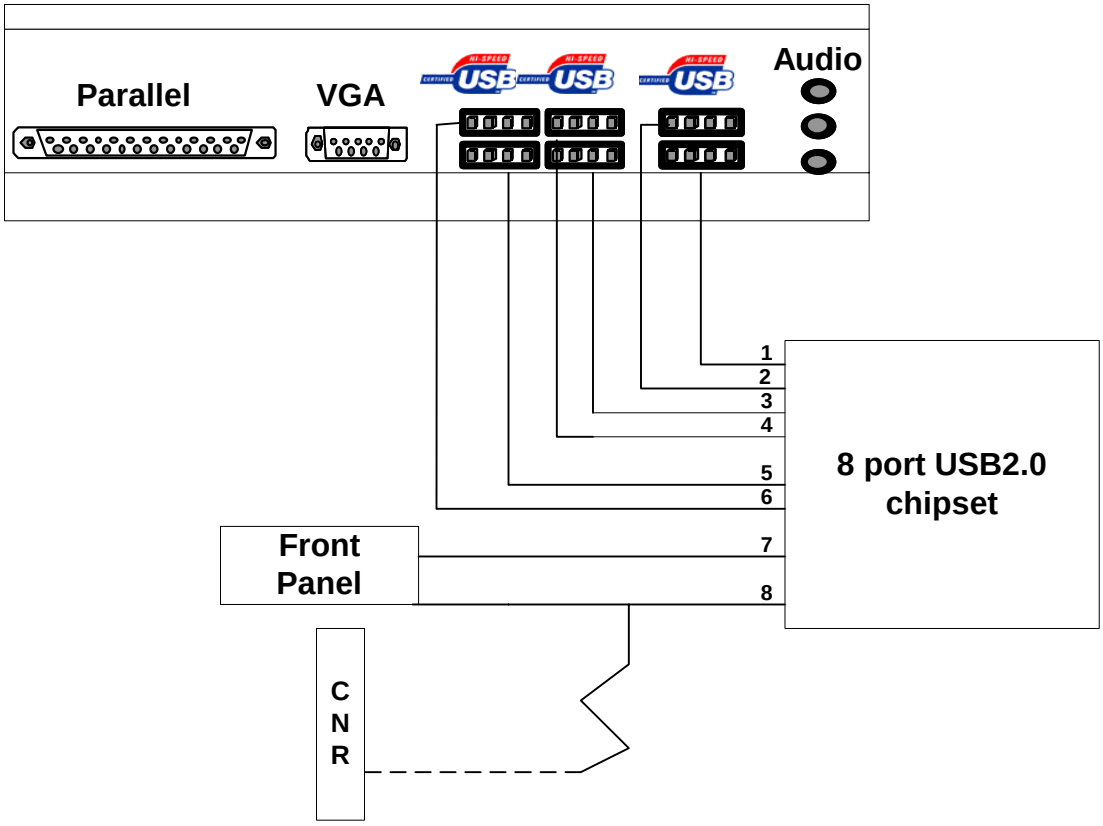
With six USB2.0 ports integrated into the Intel chipset, we can also add a USB1.1 hub to increase the number of ports. This way we gain four more USB1.1 ports on top of the standard 6 USB2.0 ports that we get with the Intel chipset. Note that the USB ports have been grouped together. This may be another option as serial and PS/2 ports are removed.

This option gives us 2 Hi-Speed USB ports routed to the front panel, one Hi-Speed USB to CNR, two Hi-Speed USB ports to the back panel, and the final Hi-Speed USB port routed to the Super I/O Hub. Then, the final two back panel ports are USB1.1. This solution gives us four back panel, two front panel, and full CNR to USB.



Option #6

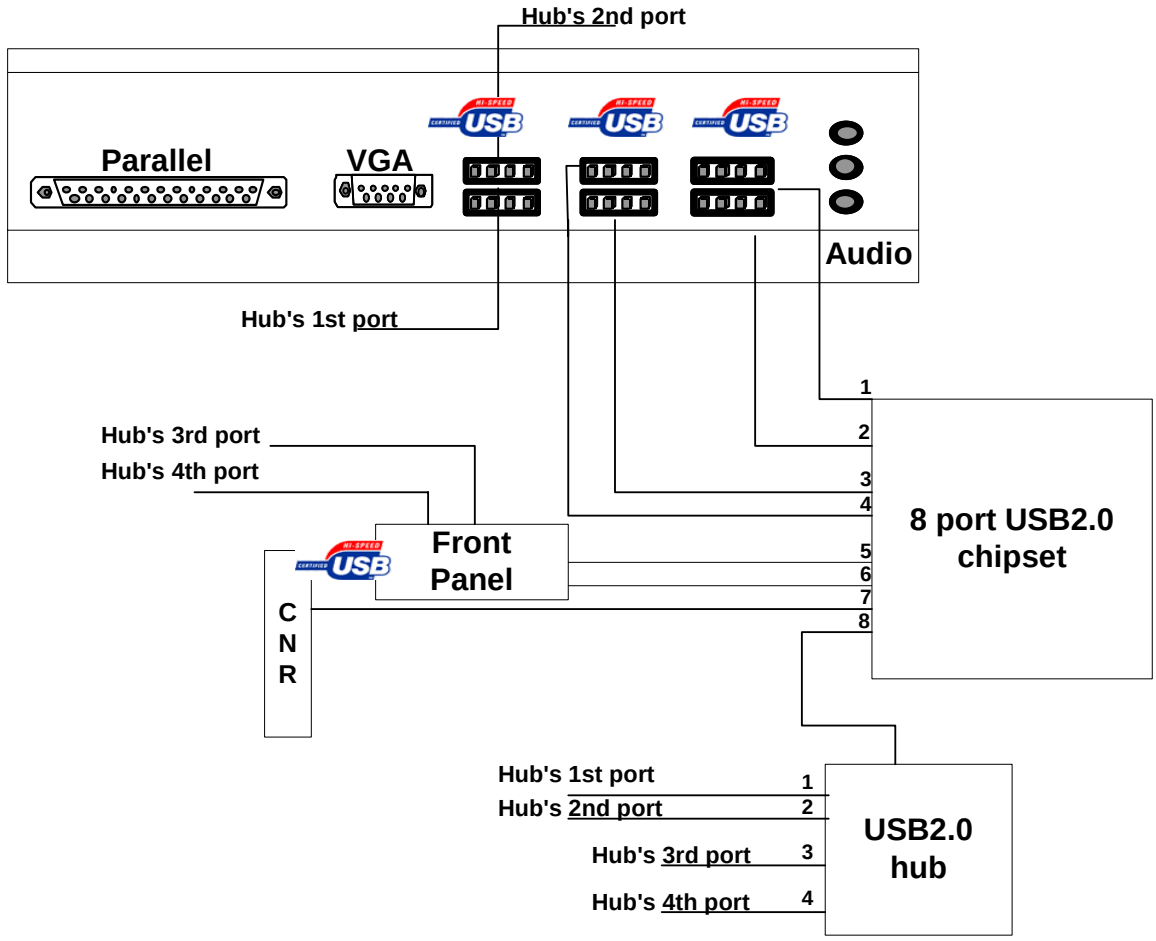
One possibility is that in late 2003 Intel chipsets may be integrated with 8 Hi-Speed USB ports. This allows for even more peripherals to be connected to the Hi-Speed interface. This solution provides two USB2.0 ports in the front panel, five USB2.0 ports to the back panel, with an option for the sixth if we do not route to CNR.
Note that the USB ports have been grouped together. Note that as serial and PS/2 ports are removed, USB ports can be grouped together.



Option #7

This option also demonstrates 8 ports integrated into the chipset, and increases the USB port count from Option#6 by adding a Hi-Speed USB2.0 hub. The hub provides four more Hi-Speed USB ports.

Looking at the graphic below, the back panel has three double-stacked USB2.0 ports. Also, there are four Hi-Speed USB ports to the front panel, as well as one Hi-Speed USB port to CNR. It is also important to note that one port from the chipset must be routed to the hub (port #8).



V. Conclusion

The next-generation hand-held, digital technology, and storage devices are constantly evolving, and it is necessary for all PC's to come integrated with Hi-Speed USB. This peripheral standard is up to 40 times faster than the USB1.1 standard. Hi-Speed USB is an evolutionary step that increases performance capabilities as well as makes things simpler for the end-user.

Not only has Hi-Speed USB broadened the market for new and higher performing PC peripherals, it is replacing USB1.1 on all future computers. Also, it is important to keep in mind that by 2003 systems will only provide Hi-Speed USB2.0. This will eliminate the need to worry about mixed ports and create simpler routing and configuration models for OEMs and end-users. Intel integrates its Hi-Speed USB support on its desktop boards; this allows routing to communication and network riser (CNR). Also, it provides bandwidth for future technologies, such as wireless 802.11b and 802.11a through a CNR card.

As USB allows for greater bandwidth, there will be a correlation in the number of ports required on a motherboard. From 2001 to 2003, routing anywhere from four to eight USB ports can be complicated. Especially when USB1.1 hubs and USB1.1 controllers can be added to the mix that now includes the faster speed USB2.0 hubs and controllers. However, by looking into the future we can plan ahead for the number of USB ports we will need. This white paper demonstrated a list of possible solutions as the industry continues to transition from USB1.1 to Hi-Speed USB2.0 technology.